(12) UK Patent Application (19) GB (11) 2 219 624 (13) A

(43) Date of A publication 13.12.1989

(21) Application No 8813617.1

(22) Date of filing 09.06.1988

(71) Applicant
J H McLoughlin
43 Goodway Road, Solihull, West Midlands,
B92 9DH, United Kingdom

(72) Inventor
J H McLoughlin

(74) Agent and/or Address for Service
Brookes Martin & Wilson
Prudential Buildings, 5 St Philips Place, Birmingham,
B3 2AF, United Kingdom

(51) INT CL⁴
H01T 13/54

(52) UK CL (Edition J)
F1B BCAF BCAT BCAV

(56) Documents cited
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(58) Field of search
UK CL (Edition J) F1B
INT CL⁴ H01T 13/00 13/02 13/04 13/05 13/06 13/08
13/10 13/12 13/14 13/16 13/18 13/20 13/22 13/24
13/26 13/28 13/30 13/32 13/34 13/36 13/38 13/39
13/40 13/41 13/42 13/44 13/46 13/48 13/50 13/52
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(54) I.c. engine spark plug

(57) A pre-combustion chamber 52 is defined by a ceramic member 40 or a three-armed silicon carbide earth electrode (10, Fig. 1) and outwardly projecting portions 41 or an annular flange (11) are located between ceramic buttons 43, 44 with Belville loading washers 45. The walls of the chamber 52 reach a temperature of 1000°C and a petrol-air mixture heated in the chamber is ignited to ignite the remainder of the mixture in the engine cylinder.

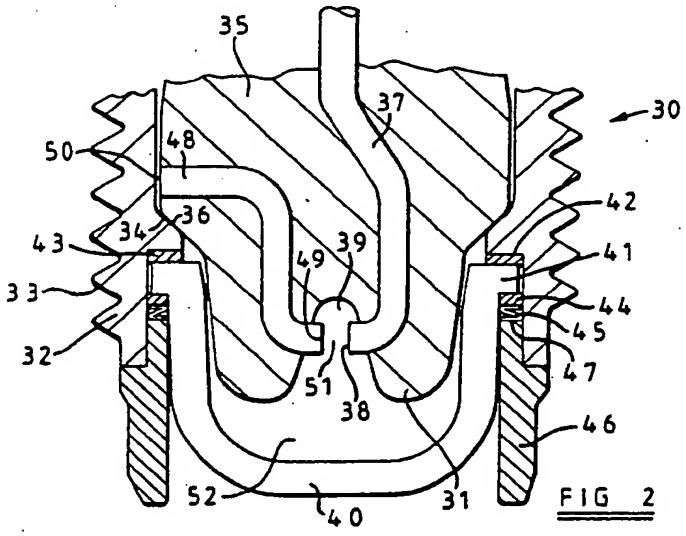

FIG 2

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1982.

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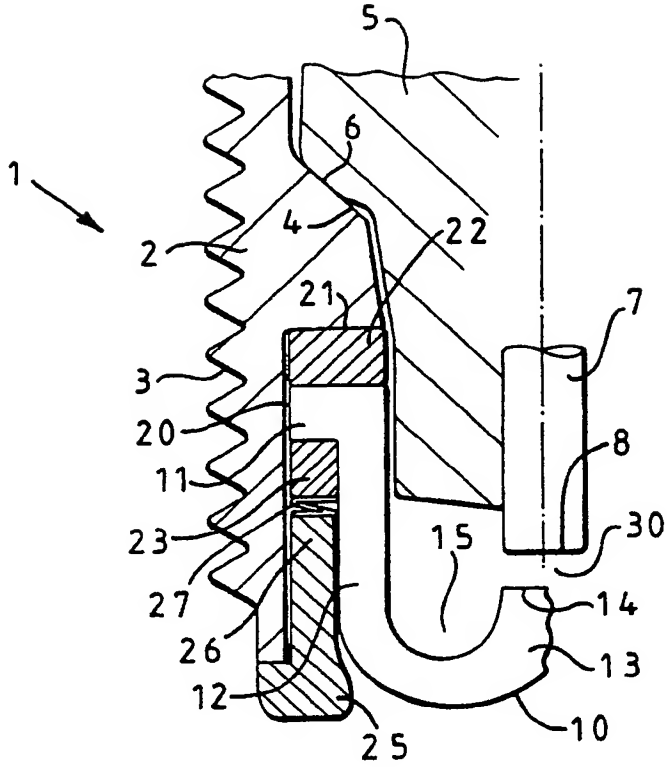

FIG 1

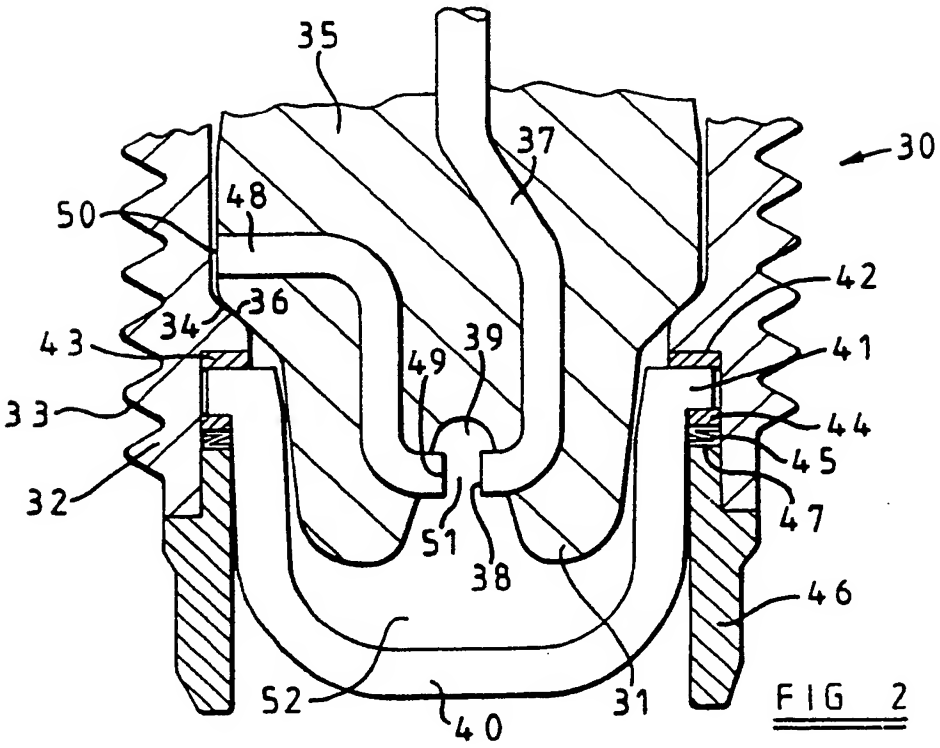

FIG 2

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IMPROVED SPARK PLUG

The present invention relates to an improved form of spark plug for an internal combustion engine.

The standard form of spark plug for an internal combustion (i.c) engine, consists of a central electrode and one or more side electrodes between which there is a defined gap, the plug extends into the i.c engine cylinder. A spark travelling between the central and side electrodes fires a compressed air/fuel mixture in the cylinder to provide motive power. However the relatively slow burn of the mixture in the cylinder leads to incomplete combustion resulting in dirty exhaust gases and relatively poor efficiency. Furthermore if an i.c engine using air/fuel mixtures is tuned for "lean burn" in order to improve the cleanliness of the exhaust gases, then there are frequently additional ignition problems especially at start up.

I have now found that if a spark plug is designed to initially ignite a small amount of air/fuel mixture in a pre-chamber, which chamber is in open contact with the cylinder, then the products of the initial combustion when exhausted into the main cylinder ignite the bulk of the mixture with a high degree of efficiency resulting in more complete combustion giving improved power and cleaner exhaust gases. Additionally the mixture in the pre-chamber is preheated by the elements forming the sides of the pre-chamber, thus leading to improved ignition of the mixture in the pre-chamber,

From one aspect therefore, the present invention provides a method of igniting a compressed fuel/oxygen containing gas mixture, e.g; petrol/air, in a cylinder of an i.c engine, wherein a portion of the mixture is preheated and then ignited, e.g in a pre-chamber, and the combustion gases therefrom used to ignite the remainder of the mixture contained in the cylinder.

From another aspect the present invention provides a spark plug for use in igniting a compressed fuel/oxygen containing gas mixture contained in a cylinder of an i.c engine, said plug comprising; an electrically conductive hollow body; a dielectric core member at least partially contained within said hollow body and having an end portion; a first electrode extending substantially concentrically through said core member and providing a first tip below the said end portion; a second electrode including a second tip opposed to said first tip and spaced a defined distance therefrom to provide a spark gap; and first means extending about said spark gap to provide a pre-chamber, bounded by said means and said core member end portion, in open communication with said cylinder.

The first means extending about the spark gap may take any form that effectively isolates a small proportion of the mixture in the cylinder whereby the proportion of mixture is first ignited and there is in the order of, a millisecond delay before the bulk of the mixture in the cylinder is ingited.

The said first means may include portions extending towards the inner wall of the hollow body for positioning

adjacent corresponding inwardly directed portions of the said wall, the means being retained in position in the body by second means acting to urge the first means against said inwardly directed wall portions. Preferably thermal barrier means are positioned between at least the said portions and the inwardly directed wall portions to reduce the temperature gradient therebetween.

Thus the pre-chamber may be formed by arranging that the first means and the outer electrode are the same and form an open cage extending below the core end portion and the central electrode tip and including an upwardly directed lower electrode tip spaced from said central electrode tip. Preferably the core electrode and the outer electrode are both formed of conductive ceramic such as silicon carbide; in some forms of the invention the electrode may however, be of conventional metal.

The plug may be provided with a protective shroud extending around and below the outer electrode.

In such a plug designed to be used with petrol/air mixtures the pre-chamber walls formed by the said means are preferably at a temperature of about 1000°C, that is just below the normal mixture ignition temperature, typically 1100°C. Pre-heating of the mixture in the pre-chamber, by the chamber walls, improves the ignition of lean burn mixtures and, in addition, allows higher air-fuel ratios to be used than are possible with conventional spark plugs.

The invention will now be described with reference to the accompanying drawings in which

Figure 1 is a diagrammatic representation in part section of a portion of a first embodiment of a spark plug of the present invention, and

Figure 2 is a diagrammatic representation in part section of a portion of a first embodiment of a spark plug of the present invention.

In Figure 1 a spark plug, generally indicated at 1, comprises a metal body portion 2 having a conventional thread 3 and an upper inner shoulder 4. A conventional ceramic (Al_2O_3) core 5 is contained within the body 1 and shaped to engage gas tight seal 6 located on shoulder 4.

The central core electrode 7, formed from conductive silicon carbide, extends through the core 5 to provide a tip 8 projecting below the core. An outer electrode, generally indicated at 10 and also formed from conductive silicon carbide, consists of an annular upper flange portion 11 from which extend three arms 12 equidistantly spaced thereabout. Arms 12 extend downwardly below tip 8 of electrode 7 and have an upwardly extending portion 13 providing a J-shaped configuration for each arm element, the elements constituting the walls of the pre-chamber 15. The four portions 13 combine below tip 8 to provide a lower electrode tip 14 opposite the tip 8. The distance apart of the electrode tips 7 and 8 provide a spark gap 30, the gap dimensions being determined during manufacture.

Flange portion 11 of electrode 10 extends into an annular passageway 20 between the body 2 and core 5 formed by machining away the lower section of body 2. The upper end of the passageway 20 is closed by shoulder 21.

The annular portion 11 is retained in the passageway 20 between upper and lower annular ceramic "buttons" 22 and 23 which provide a thermal barrier thereby reducing the temperature gradient between the metal and ceramic component and limiting the risk of thermal stress crack propagation in the ceramic.

An annular shroud 25, formed of a mild steel, is secured to the bottom of body 1 by welding and serves to protect the outer electrode 10. An upper portion 26 of shroud 25 extends upwardly between arm 11 of electrode 10 and the inner wall of body 1 towards button 23. A Belville washer 27 positioned on the upper surface of portion 26 and acting upon the lower surface of button 23 urges button 23, annular flange 11 and button 22 upwards against shoulder 21 of passageway 20 whereby the outer electrode 10 is firmly retained in position.

Small gaps are provided between the portions of electrode 10 and metallic components of the plug body and shroud 25 to allow for differential expansion during use. The gap between flange 11 and the body 2 of the plug is, however, sufficiently small to avoid any difficulty with passage of high voltage electrical power between the two components of the plug.

When in use, with the plug located in the cylinder of an i.c engine containing a petrol/air mixture under compression, the spark between electrodes tips 8 and 14 initially ignites the small amount of mixture in pre-chamber 15. The combustion gases from this ignition are then

exhausted into the bulk mixture in the cylinder releasing very high energy, perhaps as much as one thousand times the spark ignition energy, to ignite the bulk mixture. The high ignition energy results in more rapid combustion of the mixture and thereby increased power and cleaner exhaust gases. The temperature of the walls of the pre-chamber may reach a temperature just below the ignition temperature of the compressed petrol/air mixture, i.e to about 1000°C. In consequence the combustion mixture contained in the pre-chamber is pre-heated thus significantly improving ignition of that mixture especially with "lean burn" engines.

The embodiment illustrated in Figure 2 of the drawings comprises a spark plug, generally indicated at 30, having a metal portion body 32 with conventional thread 33 and an upper inner shoulder 34. The ceramic (Al_2O_3) core 35 is contained within the body 32 and is shaped to engage a gas tight seal 36 located on shoulder 34 of body 32. The lower end 38 of core 35 is lobed to define a re-entrant portion 39.

The central core electrode 37 is formed of conventional alloy material and extends through core 35 into the entrance portion 39 to provide a tip 38. A second electrode, also formed of conventional alloy material, extends from the side of core 35 into re-entrant portion 39 to provide a tip 49. Electrical contact between the second electrode 48 and the body 32 is through the narrow gap 50. The spark gap formed between tips 38 and 49 of electrode 37 and 48 is defined during manufacture.

A U-shaped ceramic member having circular cross section and having outwardly extending shoulders 41 is located in an annular passageway formed between body 32 and core 35 by machining away part of the lower section of body 32 to provide shoulders 42. Outwardly projecting portions 41 of member 40 are urged against ceramic buttons 43 located against shoulders 42 by Belville washers 45 which act upwardly against a second set of thermal barrier ceramic buttons 42 located between the Belville washers and portions 41. A protective shroud 46 extends upwardly inside the body of the plug to provide shoulders 47 against which the Belville washers 45 are located. A pre-chamber 52 is defined by ceramic member 40 and the lobed portion 38 of core 35 and includes the re-entrant portion 39.

The plug of this embodiment operates in substantially the same manner as the plug described with reference to Figure 1 and provides greater efficiency and cleaner exhaust gases than conventional plugs.

CLAIMS

1. A method of igniting a compressed fuel/oxygen containing gas mixture in a cylinder of an internal combustion engine wherein a portion of the mixture is pre-heated and ignited and the combustion gases therefrom used to ignite the remainder of the mixture contained in the cylinder.

2. A method according to claim 1 where the portion of the mixture is heated in a pre-chamber contained within the said cylinder.

3. A method according to claims 1 or 2 wherein the fuel/oxygen containing gas mixture is a petrol/air mixture.

4. A method according to any one of claims 1, 2 or 3 wherein the said portion is pre-heated to a temperature of or approaching 1000°C before ignition.

5. A method according to any one of claims 1 - 4 wherein the delay between ignition of the portion of the mixture and the ignition of the remainder of the mixture is in the order of one millisecond.

6. A spark plug for use in igniting a compressed fuel/oxygen containing gas mixture in a cylinder of an internal combustion engine comprising;

an electrically conductive hollow body;

a dielectric core member at least partially contained within said hollow body and having an end portion;

a first electrode extending through said core member and providing a first tip adjacent the said end portion;

a second electrode including a second tip opposed to said first tip and spaced a defined distance therefrom to provide a spark gap;

and first means extending about said spark gap to provide a pre-chamber bounded by said means and said core member end portion and in open communication with said cylinder.

7. A spark plug according to claim 6 wherein said first means includes portions extending towards the inner wall of the hollow body for positioning adjacent correspondingly inwardly directed portions of said wall, the means being retained in position in the body by

second means acting to urge the first means against said inwardly directed wall portions.

8. A spark plug according to claim 7 wherein a thermal barrier means is positioned between said first means portions and the inwardly directed wall portions to reduce the temperature gradient therebetween.

9. A spark plug according to claim 7 or 8 wherein the said first means comprises a U-shaped ceramic member having outwardly extending shoulders at the upper ends of the arms of the U, the inwardly directing portions of the said wall comprising shoulders towards which the said outwardly directed portions are urged.

10. A spark plug according to claim 8 or 9 wherein the second means is a belville washer.

11. A spark plug according to any one of claims 6 - 10 wherein the said first means and second electrode are the same and wherein the electrode forms an open cage extending below the core end portion and said first electrode tip and includes an inwardly directed second electrode tip.

12. A spark plug according to any one of claims 6 - 11 wherein the first and second electrodes are formed of conductive ceramic materials.

13. A spark plug according to claim 12 wherein the conductive ceramic material is silicon carbide.

14. A spark plug according to any one of claims 6 - 13 wherein a protective shroud extends around and below the said second electrode.

15. A spark plug according to claim 6 substantially as herein described with reference to Figures 1 or 2 of the drawings.

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